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121. Proposed by AUGUSTUS J. REEF, Student in Illinois State Normal University, Carbondale, Ill.

Construct a triangle having given its three medians. [From Wentworth's *Plane and Solid Geometry.*]

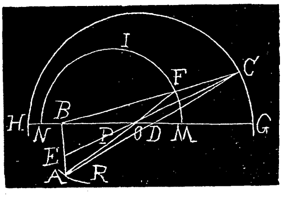
I. Solution by M. A. GRUBER, A. M., War Department, Washington, D. C.; ALOIS F. KOVARIK. Instructor in Mathematics, Decorah Institute, Decorah, Ia.; CHAS. C. CROSS, Whaleyville, Va.; and the PROPOSER.

Each median intersects the other medians at a common point two-thirds of the distance from the vertex to the middle of the opposite side.

Let AF, BD, and CE be the three medians of a triangle.

Trisect each of the medians.

Take any point O as a center, and with a radius equal to two-thirds of CE, the greatest median, describe the semi-circumference HCG.



Draw the diameter HOG.

With a radius equal to two-thirds of BD, the next largest median, and O as a center, intersect HOG at B.

Bisect, respectively, HB at N, BG at M, and MN at P.

Then, with NP, $=PM$, as a radius and P as a center, draw the indefinite arc $NIFM$. *This arc bisects any straight line drawn from point B to outer arc.*

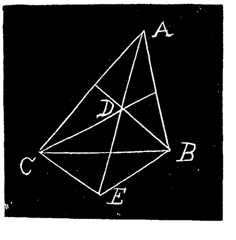
With a radius equal to one-third of median AF and O as a center, intersect arc $NIFM$ at F; and with a radius equal to two-thirds of AF and O as a center, describe the indefinite arc AR.

Through F and O draw line FA terminating in arc AR. Also draw lines BA and AC.

Then will ABC be the required triangle.

II. Solution by HENRY HEATON, M. Sc., Atlantic, Ia.; ELMER SCHUYLER, Reading, Pa.; J. D. CRAIG, A. B., New Germantown, Pa.; J. SCHEFFER, A. M., Hagerstown, Md.; P. S. BERG, B. Sc., Principal of Schools, Larimore, N. D.; COOPER D. SCHMITT, A. M., Professor of Mathematics, University of Tennessee, Knoxville, Tenn.; GAYLOR CAMERON, Tiffin, O.; and W. H. DRANE, Graduate Student, Harvard University, Cambridge, Mass.

Construct the triangle DEB such that DE, DB, and EB shall be, respectively, equal to two-thirds the given medians from the angles A, B, and C, of the required triangle.



Draw EC parallel to BD, and DC parallel to BE, meeting in C.

Prolong ED to A, making $DA=ED$. Join AB and AC.

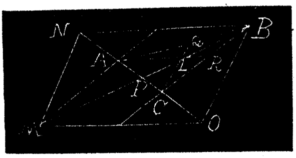
Then will ABC be the the required triangle.

The demonstration is obvious.

III. Solution by J. W. YOUNG, Columbus, Ohio, and G. B. M. ZERR, A. M., Ph. D., Professor of Mathematics and Science, Chester High School, Chester, Pa.

Construct a parallelogram such that MN, MO, and MB shall be double the given medians.

Draw the other diagonal NO. Trisect NO in A, C. The triangle ABC is the one required, since PB is evidently one of the medians given, and the other medians QC and AR are, respectively, equal to $\frac{1}{3}OB$ and $\frac{1}{3}NB$. This is clear, from the considerations of the similar triangles AOB and AQC ($AQ=\frac{1}{2}AB$, $AC=\frac{1}{2}AO$, $\therefore$ $QC=\frac{1}{2}OB$), and NCB and ACR ($AC=\frac{1}{2}NC$, $RC=\frac{1}{2}BC$, $\therefore$ $AR=\frac{1}{2}NB$).



CALCULUS.

90. Proposed by ELMER SCHUYLER, Reading, Pa.

Prove that the evolute of the logarithmic spiral is an equal logarithmic spiral. [From Byerly's *Integral Calculus.*]

I. Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Mathematics and Science, Chester High School, Chester, Pa.; GEORGE LILLEY, Ph. D., L. L. D., Professor of Mathematics. State University, Eugene, Ore.; WALTER H. DRANE, A. M., Graduate Student, Harvard University, Cambridge, Mass.; and ELMER SCHUYLER, Reading, Pa.

The intrinsic equation to the logarithmic spiral $s=k(c^t-1)$.

$ds/dt=kc^t\log c$, for the evolute $\sigma=\pm(ds/dt)]_0^t$.

$\therefore$ $\sigma=kc^t\log c-k\log c=k\log c(c^t-t)$.

$\therefore$ $\sigma=k'(c^t-1)$, an equal spiral.

II. Solution by J. SCHEFFER, A. M., Hagerstown, Md.; and COOPER D. SCHMITT, A. M., Professor of Mathematics, University of Tennessee, Knoxville, Tenn.

Let P be a point of the given curve $r=a^\theta$, O the center of curvature, PQ a tangent at P, $PO=\rho$, $SQ=p=$the perpendicular from S upon PQ, $SP=r$, $SO=r'$, SM perpendicular to OP and$=p'$.

The pedal equation of the given curve $r=a^\theta$ is $r=p\sqrt{[1+(\log a)^2]}$; we also have $r'^2=\rho^2+r^2-2\rho p$, but $\rho=r\sqrt{[1+(\log a)^2]}$.

$\therefore$ $r'=r\log a$, and since $p'^2=r^2-p^2$, we have

$$p'^2=\frac{r^2(\log a)^2}{1+(\log a)^2}. \quad \therefore p'=\frac{r\log a}{\sqrt{[1+(\log a)^2]}}. \quad \therefore p'=\frac{r'}{\sqrt{[1+(\log a)^2]}},$$

or, $r'=p'\sqrt{[1+(\log a)^2]}$, which is the pedal equation of the evolute and exactly like the pedal equation of the logarithmic spiril.

III. Solution by CHAS. E. MYERS, Canton, Ohio; and P. H. PHILBRICK, M. S., C. E., Chief Engineer for Kansas City, Watkins & Gulf Railway Co., Lake Charles, La.

Let $r=$the radius vector of the given curve, $p=$the perpendicular on the tangent, $r_1=$the radius vector of the evolute, $p_1=$the perpendicular on its tangent, and $R=$the radius of curvature.

We have for the curve, $r=cp$.......(1).